EXHIBIT 113

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51 FR 22612-01
51 FR 22612-01, 1986 WL 103293 (F.R.)
(Cite as: 51 FR 22612)

RULES and REGULATIONS

DEPARTMENT OF LABOR

Occupational Safety and Health Administration

29 CFR Parts 1910, 1926

[Docket No. H-033C]

Occupational Exposure to Asbestos, Tremolite, Anthophyllite, and Actinolite

Friday, June 20, 1986

***22612** AGENCY: Occupational Safety and Health Administration, U.S. Department of Labor.

ACTION: Final rules.

SUMMARY: In these final standards, the Occupational Safety and Health Administration (OSHA) amends its present standard (29 CFR 1910.1001) regulating occupational exposure to asbestos. The standards published today establish a permissible exposure limit of 0.2 fiber per cubic centimeter of air (f/cc), determined as an 8-hour time-weighted average airborne concentration. The standards apply to all industries covered by the Occupational Safety and Health Act, including the construction and maritime industries and general industry. Separate standards and separate statements of reasons (Summary and Explanation sections) have been developed to apply to general industry (including maritime) and to construction, because the differences in exposure and workplace conditions in general industry and construction worksites warrant separate treatment. The standards will be codified in 29 CFR Parts 1910 and 1926, OSHA's General Industry and Construction standards, respectively. The basis for promulgation of these regulations is a determination by the Assistant Secretary that employees exposed to asbestos, tremolite, anthophyllite, and actinolite face a significant risk to their health and that these final standards will substantially reduce that risk. The record in this rulemaking demonstrates that employees occupationally exposed to asbestos are at risk of developing such chronic diseases as asbestosis, lung cancer, pleural and peritoneal mesothelioma, and gastrointestinal cancer.

The standards also provide for requirements for methods of compliance, personal protective equipment, employee monitoring, medical surveillance, communication of hazards to employees, regulated areas, housekeeping procedures, and recordkeeping. An "action" level of 0.1 f/cc as an 8-hour time-weighted average is established as the level above which employers must initiate certain compliance activities, such as employee training and medical surveillance. Where the employer

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*22633 RL/RE)-1=KLx f dt-10

(Eq. 2)

showing, on the left-hand side, the excess relative risk (excess SMR) as a function of KL and total dose (fibers times years). It is this form of the equation that is used to derive the individual KL's for each of the eight studies. These eight KL's are used to derive one overall KL for lung cancer. Then the excess risk is computed for each five-year age interval; the overall lung cancer risk is then computed as the sum of the risks in each of the five-year intervals from age 25 to age 70. The excess risk is expressed as the number of additional lung cancer deaths per 1000 workers exposed for a specific time period.

Evidence of the linear dose-response relationship for lung cancer is found in several well-conducted epidemiologic studies that examined lung cancer mortality in relation to cumulative asbestos exposure in the workplace (for example, Henderson and Enterline, 1979, Ex. 84-48; Liddell et al., 1977 Ex. 84-59, and Dement et al., 1982, Ex. 84-35). In the three studies cited above, workplace asbestos air concentrations were available from measurements made in the worksite studied. Although the studies differ in the magnitude of the risk found (discussed later in this section), all three demonstrate a linear relationship over the entire range of observation.

As stated in the November proposal, other scientific and scientific groups who have attempted to estimate risk from asbestos exposure have used the linear model for lung cancer [Crump, Ex. 85-22, British Advisory Committee on Asbestos. Ex. 84-216, Acheson and Gardner, Ex. 84-243, Selikoff, Ex. 82-2, EPA, Ex. 84-180, CHAP, Ex. 84-256, National Research Council/National Academy of Sciences, Ex. 321]. The model is generally accepted and OSHA believes use of the linear model for predicting lung cancer due to asbestos exposure is reasonable and well-supported. Although participants in the rulemaking pointed to the uncertainty associated with the use of the linear model, no one suggested another model for computing the lung cancer risks.

Dr. Hans Weill elaborated on this point:

* * * As regards the shape of the dose-response slope, and operational judgment is based on the conclusion that there is currently no available evidence that convincingly proves that the slope is not linear, crossing the [excess] risk axis at the origin. This assumption (as made in the OSHA risk analysis) is justified from the observations at moderate and high levels of exposure that generally indicate linearity, which when extended downward to levels of exposure below which observations are available, are not inconsistent with linear low dose extrapolation [Ex. 99, p. 13].

And, in his testimony, Dr. Weill concluded:

Now, as far as the shape of the curve for the important malignant consequences of

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asbestos exposure, I think we are all in agreement so far today, that the evidence does not permit us, nor does concern of public health or prudence permit us for the conditions that we are concerned about, to develop on any basis other than linearity of exposure and response in a no threshold model [Tr. 6/19, p. 154].

Dr. William Nicholson of the Mount Sinai Environmental Sciences Laboratory elaborated on the rationale for the choice of the linear model for lung cancer:

In three studies in which it [the linear dose-response curve] has been demonstrated [see above Exs. 84-48, 84-59, and 84-35] the range of exposures is large, over a tenfold range of exposures, that linearity has been documented over a tenfold range of dose. Further, it has biologic plausibility [Tr. 6/19, p. 75].

This biologic plausibility was also discussed by Dr. Kenny Crump, testifying on behalf of the AIA/NA:

There is a theoretical argument (Crump et al., 1976) that suggests that cancer incidence should vary approximately linearly with dose for low doses particularly when there is an appreciable background of carcinogenesis in unexposed populations.6 . . .6 If asbestos induces cancer through the same mechanism as smoking, then there is reason to believe that the response should be approximately linear at low dose . . . just as assumed in the OSHA model [Ex. 237A, pp. 8, 25].

Though Dr. Crump noted in his testimony that the linear model for lung cancer "is a hypothesis which is by no means proven" [Tr. 7/9, p. 90], he stated during cross-examination that "all of the estimates I have made in the testimony were based upon a linear model for lung cancer" and that the linear model for asbestos and lung cancer "has been widely used" [Tr. 7/9, p. 116].

Thus, OSHA feels confident in its adoption of a linear model to predict the risk of lung cancer from asbestos exposure. The model has wide support because of its scientific plausibility and reasonableness and its prudence for use in public health decision-making.

B. Data Used in the Calculation of Individual kL's. In the November proposal [48 FR 51125], an estimate of lung cancer potency (KL) was calculated for each of 11 studies using equation 1. For studies with individual exposure data, KL was the slope of the regression equation fit to these points; for studies having only an overall risk estimate and average estimate of exposure, this single point was used in the calculation of KL. For each study, the best estimate of KL is indicated along with a range of uncertainty. The ranges given are the result of uncertainties in estimates of exposure, methodological uncertainties that led to alternate evaluations of risk or exposure, or, in some cases, statistical uncertainties associated with the use of small numbers.

The differences in the KL's among the various studies result from a number of different factors. There do appear to be actual differences in risk depending upon the nature of the asbestos exposure. One potential explanation is that

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workplaces differ with regard to fiber size distribution (long finer fibers appear to have greater carcinogenic potential than coarse fibers). For example, as several participants in the rulemaking acknowledged, there appears to be a distinct difference in the risk from mining and milling and other processes. As Dr. Nicholson summarized:

I think I stated this morning . . . the possibility that the mining work environment may demonstrate a different pre-unit risk. That is, there's three studies showing somewhat lower risks. At least two of them show, with fairly substantial data, lower risk, that that [lower risk] may be a function of the fiber size distribution in the mining environment.

One may have a much greater number percentage, of long curly fibers, which are readily counted, but are not inspired. And, thus, the fiber counts are proportionately high in that environment relative to the amount of asbestos inspired. It seems to be consistently so for chrysotile and also for amosite. For example, one finds very few cases of mesothelioma associated with amosite mining but a considerable number associated with amosite manufacturing.

And so there is perhaps a difference in the mining environment, where they are working with different type of fiber composition [Tr. 6/19, p. 127].

Thus, where airborne fibers are relatively coarse, the KL's are lower than the KL values found in studies of textile operations where fibers are fine.

Differences may also be explained by variations in study design and other factors influencing the ability to define the dose-response relationships. One of these is the limited knowledge of past fiber exposures of those populations whose mortality was later evaluated. Prior to 1970, few measurements were made in facilities using asbestos fibers. Further, those measurements that were done usually quantified all dust present in the workplace air and not just fibers. Current techniques, which involve use of membrane filters and phase contrast ***22634** microscopy for the counting of fibers longer than five micrometers, have been utilized in Great Britain and the United States only since 1964 [Ayer et al., 1965, Ex. 84-253] and have been standardized in the United States only since 1972 [Leidel], 1979, Ex. 84-62] and even later in Great Britain. In any case, sampling has occurred only in a few of the worksites studie6d, and then only occasionally. In addition, variability in work activities and in sampling circumstances add considerable uncertainty to knowledge of dose.

Some of the epidemiologic studies, including those by Dement et al. [Ex. 84- 35], Liddell et al. [Ex. 84-59] and Henderson and Enterline [Ex. 84-48], include measured air concentrations at the exposure site and used job histories of the study population to estimate exposure. In these cases the dose-response curve was calculated by estimating total asbestos exposure (in mppcf-years or in fiber-years/cc) according to the time that an individual spent at a job with a measured exposure. A conversion factor for converting from mppcf to f/cc was employed on a study-by-study basis, depending on the data available. Other epidemiological

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studies, for example those by Selikoff et al. [Ex. 84-90] and Seidman et al. [Ex. 84-87], did not have direct industrial hygiene measurements for the studied worker population. For these studies, exposure estimates were derived from industrial hygiene surveys of similar work operations and processes for which industrial hygiene data were available.

OSHA has evaluated these differences and has dealt with their implications on a study-by-study basis. Uncertainties associated with these measurements constitute much of the range of variability surrounding the KL's. Taken as a whole , the asbestos studies contain data of unusually high quality, which has enabled OSHA to make the risk estimates with a high degree of confidence.

There was considerable discussion during the rulemaking about the individual KL's for many of the studies that went into the estimation of the overall lung cancer risk, particularly the inclusion/exclusion of several of the studies in this calculation. The discussion below deals first with the comments on and adjustments to individual KL's and then discusses the impact of their inclusion in the overall estimate of lung cancer risk.

The Selikoff et al. and Seidman et al. Studies. Several participants in the hearing criticized OSHA for including the results from the Selikoff et al., 1979 [Ex. 84-87] and Seidman et al., 1979 [Ex. 84-90] studies in the calculation of KL. The major objection to the use of these studies was the lack of concurrent exposure information on the cohorts. For example, Dr. Crump noted that:

The CPSC (1983) Panel placed these two studies in a separate category because of the weakness of the exposure estimates. The Seidman et al. study also involved brief exposures (less than four years) exclusively, which makes it less suitable than other studies for estimating the effect of long term exposures [Ex. 237A, p. 26].

Dr. Weill also expressed reservations about including the Selikoff et al. and Seidman et al. studies in the overall estimation of risk [Tr. 6/19, p. 184].

Though it is true that CHAP did characterize the Selikoff et al. and Seidman et al. studies as having "Level 2 exposure data" (no job histories or industrial hygiene measurements available for the cohort, exposure estimate made from best available sources), CHAP still computed KL for these two studies with the information available. And, during cross-examination, Dr. Nicholson, a member of CHAP, indicated that CHAP did not weigh the KL values from these two studies differently from those in other studies when deriving estimates of the final potency [Tr. 6/19, p. 148]. Dr. Weill emphatically stated that inclusion of the studies in the risk analysis was "not a fatal flaw [Tr. 6/19, p. 184].

OSHA offered a full description of the exposure data used in these two studies in Exhibit 84-392. Since that time, however, new and more complete information on exposures for the Seidman et al. cohort have come to light which strengthen the case for including the results of the KL calculation in the overall estimates of

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risk. This new information is discussed below.

Although no new evidence has been brought forward on the Selikoff et al. study of insulation workers, OSHA still believes it is appropriate to include the KL from this study in determining the overall level of risk. It is the largest of all the studies (17,800 workers) and also reports the largest number of lung cancer deaths (652) and deaths from mesothelioma (180). Excluding this study would mean excluding 45% of all the asbestos-related lung cancer deaths and 84% of all the mesothelioma deaths from the overall analysis. OSHA believes it would be a serious error to eliminate such a large portion of the available data, when appropriate estimates of the exposure levels of these workers are available.

OSHA calculated the KL from the Selikoff et al. data based on average values (for duration of exposure, level of exposure and time since onset of exposure) derived from several sources. Although the use of average data and overall (average) levels of risk may not be as desirable as risks broken down by cumulative exposure, nevertheless, the estimates of KL from these data are nevertheless valid and reasonable. OSHA predicted a KL of 0.02 for the cohort, with an uncertainly band of (0.008 to 0.30). The value 0.02 is only twice the best estimate of an overall KL of 0.01 and falls well within the range of overall uncertainlty given for the overall KL, that is, 0.003 to 0.03. Thus, OSHA has not adjusted the original value of KL computed for this cohort.

The Seidman et al Update. During the course of the hearing, the testimony of several witnesses strengthened OSHA's confidence in using results from the Seidman et al. study of 820 insulation manufacturing workers. As discussed in Exhibit 84-392, while no data exist on air concentrations at the time the Paterson factory operated, data do exist on air concentrations in two plants that manufactured the same products with similar fiber and machinery. One of these plants, in Tyler, Texas, opened in 1954 and operated until 1971. The other, in Port Allegheny, Pennsylvania, opened in 1964 and closed in 1972. Similar efforts to control dust in these newer plants were apparently made as were made in the Paterson, New Jersey plant. During 1967, 1970, and 1971, asbestos fiber concentrations in these plants were measured by the U.S. Public Health Service and were published by NIOSH [Ex. 2-12].

Participants in the rulemaking criticized the assumption that these exposure data were representative of the exposure conditions in the Paterson plant. Dr. Crump expressed his concern over the use of these data. He stated:

OSHA thus derived exposure estimates from measurements made 21 to 31 years later in the other plants in Texas and Pennsylvania. The reasonableness of these estimates is open to question. It is certainly plausible that the exposure measurements in these plants made after the dangers associated with asbestos became known were less, and perhaps far less than exposures experienced 21-31 years earlier under wartime conditions [Ex. 237A, p. 13].

Dr. Morton Corn, former Assistant Secretary for OSHA, who appeared at OSHA's

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hearing on behalf of the Building and Construction Trades Department was hired by the companies who owned the plants to recommend and install control measures in the two plants in the late 1960's. At the hearings he was asked to comment on the reasonableness of using data from Tyler, Texas and Port Allegheny to estimate ***22635** exposures in the Paterson plant. Dr. Corn responded:

I think the procedure is precisely what we're trying to do in industrial hygiene. And I would endorse trying to link similar plants where no measurements were available to other plants where measurements are available. There's no question about that.

I would classify Tyler as one of the most contaminated asbestos facilities I've ever been in. I think Tyler would be the high estimator. Port, I would consider typical of asbestos processing that I saw in those years. But Tyler was clearly a very bad facility. . . . So I don't know if averaging them, averaging might put you on the high side if you have measurements for both. I would pit you towards Tyler. . . . Tyler was a fairly startling facility [Tr. 7/3, p. 67].

Hence, given Dr. Corn's characterization of conditions in the two plants, to the extent that OSHA used data from the Tyler plant, the estimates of exposure would be overestimated, which would result in an underestimate of the potency factor, KL.

Since the time of the OSHA proposals, the Seidman et al. study has been updated to include longer followup and an expansion of the findings in terms of the jobs of the workers and estimates of the fiber exposure accumulated by the workers during their work at the amosite asbestos factory. The updated study was presented at the hearings as Exhibit 261-A. The study extended the observation period through December 31, 1982, with a total of 593 deaths. Using the data from the Tyler Texas and Port Allegheny plants, Seidman and colleagues attempted to "assign plausible estimates of the exposures likely to have been associated with particular jobs in the Paterson plant" [Ex. 261-A, p. 6]. Seidman described the process as follows:

With the aid of the expertise of Dr. William Nicholson, I've gone back to the records that were accumulated on the Paterson workers, and in conjunction with fiber counts that were available for 1967 from Port Allegheny Plant and for 1967, 1970, and 1971 for the Tyler, Texas plant, the same kind of fiber was used, the same kind of equipment was used, the same processes were used to make the same kinds of products, we arrived at approximate--we estimated--looking at what the men themselves reported as to relative levels of dustiness in the jobs they worked at. We established levels of dustiness, dust index which at first was all I thought we could work with and I realized we had specific jobs that we could even modify this with, we assigned fiber counts per cc and then were able to then, with the aid of our historical data, to make an assignment which we applied to our Paterson plant. Then with the aid of the time that the men worked, we arrived at the total work time they worked at the plant, a total work experience dosage in terms of fibers [Tr. 7/12, p. 289, emphasis added].

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As Mr. Seidman pointed out, when using the estimates of Tyler and Port Allegheny to determine exposures at the New Jersey plant, the estimates.

* * * may be somewhat on the high side to the extent that industrial hygienists tend to over-sample the dustier areas of factories. Also, there was a concerted effort to have the Paterson plant workers use respirator protectors which presumably might have reduced the exposure from inspired air while the protectors were being used. . . . It is important to realize that any overestimation there may be in the fiber counts we have assigned, will serve to underestimate the dose-response relationships associated with asbestos exposure at the Paterson plant [Ex. 216-A, p. 6].

Table 5 of Ex. 261-A shows the estimated exposures for over 30 job categories. During cross-examination, Mr. Seidman further explained:

Table 5 comes from two sources, one is internal and one is external. Internally, we had for about 40 percent of the men, a statement as to the dustiness of their job. We had--they said what their job was and how dusty it was[:] very dusty, somewhat dusty, or not dusty at all. . . . We had, for a number of jobs, what the counts--fiber counts--were for the jobs which, as I say, using the same kind of equipment, and same fiber and same kind of product, were in these plants of the same company. These were the general levels used to assign the jobs at UNARCO [Paterson, N.J.] and then modified them slightly depending on what the internal statement as to dustiness was [Tr. 7/12, p. 298- 299].

Dr. Nicholson explained further:

The exposure-response data were generated by assigning each individual in the Paterson plant an exposure as calculated above for the period of time he would have been employed in a job with that given title. The total exposure in fiber-years/ml for each individual was then calculated summing over all jobs that the individual worked in [Ex. 303].

Table 1 gives cumulative observed and expected deaths for the workers in an amosite factory categorized by estimated fiber-year exposure. As noted in Ex. 84-392, it was believed that the average exposure for this population was approximately 35 f/ml, and this was the value used to calculate the original value of KL for this cohort. However, in this updated analysis the average exposure was discovered to be closer to 50 f/ml [Tr. 7/12, p. 291]. Mr. Seidman indicated that the high number resulted when the estimates of fiber counts were "weighted by the kinds of jobs that the Paterson people had, [and] the number of people working at the jobs they had in the Paterson plant" [Tr. 7/12, p. 294]. Seidman went on to testify that "If you look at the historic data, there are ranges which go higher, but not on the averages. There are ranges, there are samples that go into the 200's" [Tr. 7/12, p. 295]. He noted, however, that the estimate of 50 f/cc "seems pretty reasonable and plausible to me" [Tr. 7/12, p. 295].

As was pointed out by Mr. Hardy, representing the AIA/NA, during cross-ex-

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amination, the dose-response curve appears to cross the y-axis at a level above zero. However, Mr. Seidman was clear that possible underestimation errors in the measurements could not account for such differences. He commented--

To move them [the risk points at each dose level] far enough over so that the point on the straight line from this kind of material is going to come to zero [excess risk] on a straight line fit, they'd have such a cloud of dust, they wouldn't see each other at the next bench. . . . People couldn't work in such [conditions]--even the people who need a job desperately couldn't work in such an atmosphere [Tr. 7/12, p. 308].

Table 1.--Cumulative Observed and Expected Deaths in an Amosite Asbestos Factory, 1941-45, by Estimated Fiber Exposure--Seidman.1984 [FN1]

Cumulative exposure f-y/ml	Midpoint	Lung cancer		
		Observed	Expected	SMR
<6	(3.0)	14	5.31	[FN2] 264
6.0 to 11.9	(9.0)	12	2.89	[FN3] 415
12.0 to 22.9	(18.5)	15	3.39	[FN2] 442
25.0 to 49.9	(37.5)	12	2.78	[FN2] 432
50.0 to 99.9	(75.0)	17	2.38	[FN2] 714
100.0 to 149.9	(125.0)	9	1.49	[FN2] 604
150 to 249.9	(200.0)	12	1.32	[FN2] 909
250 plus	(250.0)	11	0.94	1,170
Total	----------	102	20.51	49

1 From Table 7, Seidman, 1984, Ex. 261-A.
2 p<.001.
3 p<.01.

In its original evaluation of this study, OSHA used overall averages (SMR=4.46, 35 f/cc, 1.46 years) to compute the KL [0.068=(4.46-1)/(35x1.46)]. Substituting the overall values from the updated study gives a slightly smaller value of KL [0.054=(4.97-1)/(50x1.46)]. In addition, the updated and expanded data base now provides enough data to perform a dose-response regression for the lung cancer data. The data are found in Table 1. As with other data sets, it may be speculated that there is greater uncertainty in the estimates at lower doses. This may be adjusted for by forcing the curve through the origin. Regressing excess SMR on the midpoints of dose gives an estimate of KL of 0.045. Although this value of KL is somewhat lower than the originally predicted value of 0.068, OSHA has greater confidence in it as an accurate ***22636** predictor of the asbestos potency in this production population.

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The Henderson and Enterline study. OSHA calculated the value of KL based on the mortality experience of 1075 retirees from an asbestos products manufacturing plant [Ex. 84-48] by computing the slope of the dose-response relationship from the linear regression (KL=0.0066). Henderson and Enterline had presented exposure data in terms of total dust measured in millions of particles per cubic foot, and hence a factor was needed to convert from particles to fiber count. OSHA employed the value 1.4 f/ml/mppcf, based on the work of Hammad in cement plants, which gives a best estimate of KL of 0.0047.

Crump has pointed to what he believes to be "considerable uncertainty in the methods used by OSHA to convert from particles to fibers" [Ex. 237A, p. 14]. Citing the CHAP [Ex. 84-256], he recommends that a conversion factor of 2 should have been employed, giving a KL of 0.0033. He also notes that "Enterline himself employed a conversion factor of 3.0 (Enterline 1981) [Ex. 84-127]" [Ex. 237A, p. 15]. However, when Dr. Enterline testified before the Ontario Royal Commission in June of 1981, he expressed considerable doubt about the conversion factor of 3, noting "I don't know how anybody comes up with a number like that anyhow" [Ex. 85-2, p. 53]. Enterline also noted that the conversion factor depended on the operation and that "I think, in asbestos cement, maybe that's [3's] the wrong number" [Ex. 85-2, p. 53]. In addition, in the same footnote [Ex. 84-127] cited by Dr. Crump, Dr. Enterline noted that the British Advisory Committee on Asbestos used conversion factors of 1, 2, and 5 f/cc/mppcf and that "the most conservative estimate of response at low doses in terms of protecting the public would result from assuming a low conversion factor" [p. 42]. Whereas CHAP employed a slightly higher conversion factor, it also noted that--

* * * since follow-up of this group began at age 65, it is essentially a study of a survivor population and as such may have underestimated the maximum relative risk actually experienced by the entire cohort. If this peak relative risk provides the best basis for predicting the long-term experience of individuals exposed at lower levels, then the fitted slope should be increased perhaps by a factor of 2.0 [Ex. 84-256, II-102].

CHAP made such an adjustment in its estimate of the slope to account for these biases (Ex. 84-256, II-100]. Therefore, given the fact that CHAP recommends a value of KL considerably higher than that put forth by OSHA in the November and April proposals and since Dr. Crump has suggested a value somewhat lower, OSHA believes that its estimate of 0.0047 for KL represents a reasonable median estimate of the potency factor for lung cancer in this study population. As noted in Ex. 84-392, however, "A study of a retiree cohort with these characteristics would understate mortality by as much as 62% relative to the maximum observable risk" [p. 30]. Thus accounting for this possible underestimation, and with regard to the variation in possible conversion factors, the range of uncertainty around this value may extend from 0.0022 to 0.0106.

The Finkelstein Study. Finkelstein established a cohort of 241 production and maintenance employees from records of an Ontario asbestos cement factory. OSHA

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computed a KL for this cohort based on an average cumulative 18-years exposure of 112.5 f-y/ml for the production workers alone. This group had an SMR of 850, based on 17 observed lung cancer deaths versus 2 expected. These data produced a summary KL of 0.067 (Ex. 84-392, p. 33]. OSHA noted some uncertainties in this estimate, particularly because the two lowest exposure categories show risk increasing steeply with exposure, whereas the highest exposure category showed a cancer rate lower than that of the lowest exposure group. OSHA speculated in the proposal that this inconsistency may be due to the small number of deaths in each category.

Several participants raised the question of the suitability of using this value of KL in the overall estimate of KL. In particular, Dr. Crump pointed to the lack of a dose-response relationship for lung cancer in this cohort, quoting the CHAP conclusion that "no sensible dose-response for lung cancer can be inferred from these results" [Ex. 237A, p. 28]. CHAP noted that:

* * * possible explanations for these results are incorrect exposure estimates and/or very high competing risks for the heavily exposed persons [Ex. 84-256, p. II-111].

It should be noted that CHAP included Finkelstein's study among those categorized in the Level 1 Exposure category, that is, having job histories and industrial hygiene measurements made at the relevant exposure site. Using the entire cohort (both production and maintenance workers), CHAP computed an SMR of 606 (20 observed versus 3.3 expected). Noting reservations about the exposure levels, CHAP gave a KL of 0.048 of this cohort [(6.06-1)/(105)].

Given the same reservations as expressed by CHAP, OSHA believes 0.048 to be a valid expression of the potency of exposure to asbestos in this population of asbestos-cement workers, and has lowered its original estimate of KL to reflect some reservations about the data.

The Dement et al. Study. OSHA calculated a lung cancer potency factor from the study of Dement and his colleagues, who investigated the mortality experience of 768 workers in a chrysotile textile products manufacturing plant. Data from impinger measurements of total dust in terms of mppcf were available since 1930 for exposures in a textile plant using chrysotile [Dement et al., 1982, Ex. 84-35]. Using a factor of 3 to convert from mppcf to f/ml (also used by CHAP), OSHA computed KL as the slope of the weighted regression of excess SMR on the midpoint of dust levels in f-y/ml. As noted in the November proposal, this produced a value of KL of 0.042. Participants in the hearing argued that this KL was overestimated because Dement and his colleagues had overestimated the SMR's by using an inappropriate control group for the calculation of the expecteds. As OSHA explained in its preliminary risk assessment, Dement et al. employed U.S. national death rates rather than local county rates for computing expected values. The authors noted that:

The choice of an appropriate comparison population for mortality analyses is dif-

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ficult and arguments could be made for using rates for a set of counties contiguous to the county in which the plant was located. However, there are serious limitations to this approach which were considered in this study and resulted in rejecting the use of local county rate. First, the county in which the plant was located is the site of a large shipyard industry with peak employment of approx. 29,000 persons in 1943 (Blot et al. 1978). Employees for this industry were largely drawn from the local population. Many of these workers are thought to have been exposed to asbestos during ship construction and repair. In an ecological study Blot et al. (1978) demonstrated an association between county lung cancer rates and shipyard employment. In a more refined case-control study, Blot et al. (1979) demonstrated a summary odds ratio of 1.6 for shipyard employment and lung cancer after adjusting for smoking, other occupations, age, race, and county of residence. These data suggest that lung cancer death rates in the area in which the plant was located are likely to be elevated by local shipyard employment.

A second factor to be considered in choosing local rates for comparison is the effect that the plant being studied might have had on local lung cancer death rates. Because of a lack of an employment record system prior to about 1930, it is difficult to estimate the exact number of persons ever employed at this plant; however, this is likely to exceed 10,000 prior to 1965. Thus [sic] could have a ***22637** significant impact of local lung cancer death rates, assuming an overall lung cancer SMR of 200 or more for these workers.

The effects of shipyard and asbestos plant employment make the use of local death rates inappropriate for this study [Ex. 84-35, p. 879-880].

In addition, state (South Carolina) mortality rates from lung cancer were similar to those of the United States. Moreover, "[A]vailable smoking data for this cohort suggest that the observed lung cancer and nonmalignant mortality excess among white males cannot be explained by cigarette smoking independent of asbestos exposure" [Ex. 84-37, p. 430].

Although Crump pointed to the arguments raised by Acheson and Gardner [Ex. 84-243] that local rates should have been preferred, OSHA found these arguments unconvincing. Crump recommended a KL of 0.023, approximately half the value of KL calculated by OSHA. Crump noted that:

* * * Not only does this modification provide a better fit to the Dement et al. data, the estimated background rate agrees closely with the 75% excess of local lung cancer rates over national rates (See Figure 3 of Acheson and Gardner, 1983 [Ex. 84-243]). The lower estimate of KL = 0.023 also reduces the discrepancy between this and other studies which show a much smaller KL.

OSHA believes that a reduction of the KL to 0.023 is inconsistent with the available data: First, Dement et al. noted that:

* * * even if rates for contiguous counties had been used . . . the expected lung

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cancer rates for white males would have been increased by only approx. 15%, not nearly sufficient for the observed excess lung cancer risk [Ex. 84-35, p. 880].

Moreover, as Dement pointed out in 1982:

* * * rates for contiguous counties for black males were approximately 45 percent below U.S. rates; thus, the overall excess among blacks is underestimated by the present study, although the numbers were small [Ex. 84- 229, p. 179].

Thus, to some extent, these overall estimates may be underestimated. Hence, OSHA concludes that its original estimate of KL for this study, 0.042, is valid and reasonable, and thus has adopted it for the final rule.

C. Calculation of the Overall KL. OSHA's best estimates of KL from the proposed rule, and the final determination of KL for each study are given in Table 2, along with a range of uncertainty. The ranges listed are the result of estimates of exposure uncertainties (usually a factor of two), methodological uncertainties that led to alternate evaluations of risk or exposure, or, in some cases, statistical uncertainties associated with small numbers. In addition to some controversy over the individual KL's, there was widespread disagreement as to which studies should ultimately be included in the determination of an overall KL for lung cancer.

Table 2.--Estimates of KL From Proposed Rule and Final Determination

	Proposal	Final	Range
Henderson & Enterline	0.0047	0.0047	(.0022-0.011)
Weill et al	0.0033	0.0033	(0.0016-0.0086)
Finkelstein	0.067	0.048	(0.033-0.13)
Peto	0.0076	0.0076	(0.0009-0.023)
Dement et al	0.042	0.042	(0.23-0.21)
Berry and Newhouse	0.0006	0.0006	(0-0.0008)
Seidman et al	0.068	0.045	(.023-.06)
Selikoff et al	0.020	0.020	(0.008-0.03)
Arithmetic Mean	0.027	0.019	----------
Geometic Mean	0.0113	0.01	----------
Median	0.0138	0.0138	----------

In its preliminary assessment, OSHA used the eight non-mining-and-milling studies to derive an overall estimate of KL of 0.01. As noted in the November proposal:

Considering the industrial processes other than mining and milling, OSHA believes 0.01 to be a reasonable estimate of KL. It is the geometric mean and median of the KL's derived from studies of asbestos manufacturing and insulation application

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processes. The geometric mean had the advantage of minimizing the influence of outlying values and a KL of 0.01 is approximately within one order of magnitude of all the estimates of KL. In sum, the KL of 0.01 is a best estimate which contains appropriate recognition of studies with higher and lower values of KL. It should be noted however, that the uncertainties around this estimate of KL are such that an appropriate estimate of KL could lie between 0.003 and 0.03 [48 FR 51125].

The distinct nature of mining-milling data (and hence, the estimate of KL from these data) has been considered earlier. There is some evidence that risks in the asbestos mining-milling operations are lower than other industrial operations due to differences in fiber size. This differential was discussed by Nicholson [Ex. 303A]. Thus, in determining the best overall value for KL for the final rule, the data from mining and milling processes were not considered.

OSHA still believes it to be valid to employ the same eight studies it used to derive the estimates for the November and April proposals. As discussed earlier, OSHA modified some of the values of KL for the final rule. Based upon these revised values, OSHA has determined that the best estimate of KL is 0.01, the same value derived for the proposals. The values given under the final estimate column in Table 2 have an arithmetic mean of 0.019 and a geometric mean of 0.01. OSHA believes it has chosen reasonable estimates for the individual KL's and has been responsive to the comments made by participants in the hearing. In some cases, OSHA has lowered its original value of the estimate of KL in light of these comments or the addition of new data indicating such a change was warranted. The end result is that these small changes in individual values have little effect on the overall KL value. This is most likely due to the Agency's choice of a reasonable KL for the proposal.

Some scientists have suggested that some asbestos processes such as asbestos textile manufacturing, may pose a greater hazard than other processes. As noted earlier, while mining and milling appear to pose a lesser carcinogenic hazard than manufacturing processes, when OSHA compared the potency factors for lung cancer (KL) among different studies of different processes, no consistent pattern of differential lung cancer risk by process emerged. Therefore, again, the choice of a midpoint unit risk for all industrial processes is a reasonable and justified choice.

In sum, the KL of 0.01 is a best estimate which contains appropriate recognition of studies with higher and lower values of KL. It should be noted, however, that the uncertainties around this estimate of KL are such that an appropriate estimate of KL could lie between 0.003 and 0.3.

As discussed earlier, Crump believed that both the Seidman et al. and Selikoff et al. studies should have been excluded from the calculation of KL. Along with the other adjustments discussed above, Crump estimated an overall KL of 0.0065. As Dr. Crump noted in his testimony:

OSHA has developed what I would term an upper limit assessment of asbestos

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risk. In dealing with uncertainty, OSHA has, in a number of instances, made assumptions that tend to minimize the possibility of underestimating the risk. In addition, the uncertainties in some of their assumptions appear to be underestimated by OSHA. The three most significant assumptions in OSHA's risk assessment that lead to upper limit estimates of risk are the assumptions of: (1) a linear dose-response relationship; (2) the same potency for all forms of asbestos; and (3) attribution of the lung cancer component of risk caused by smoking to the overall risk of asbestos [Ex. 237A, p. 4-5].

However, in addition to Dr. Crump's recommendations, several commenters noted a number of different ways for incorporating the available data into an overall estimate of risk. For example, in his written testimony, Dr. Marvin Schneiderman, who served as a member of CHAP and who was one of the reviewers of OSHA's November ***22638** proposal, suggested several other reasonable methods for producing "medium estimates." In addition to approaches taken by OSHA, Dr. Schneiderman suggested that one look only at the four studies (from the proposal) which also had data on mesothelioma (Selikoff et al., Seidman et al., Peto, and Finkelstein). This selection produced an overall estimate of KL derived from the individual KL values of approximately 0.028. He also noted the KL of 0.020 which results from use of the five U.S. studies only (Selikoff et al., Seidman et al., Henderson and Enterline, Weill et al., and Dement et al. proposed values of KL, Ex. 116, p. 7).

Schneiderman concluded that:

The selection of the value of 0.01 [by OSHA] is based both on the various averages that could be computed and also on the informal or subjective weights given to each of the studies by OSHA. If this value is in error, it is possibly biased downward by the inclusion of the miners and millers and the foreign studies. However, any error introduced by an underestimate or KL will be relatively small. Because of the changing patterns of cigarette smoking which should soon lead to reduced lung cancer mortality among younger (working-age) men, an underestimate of KL is likely to compensate for possible overestimate of lung cancer mortality in the future [Ex. 116, p., 7-8].

Other possibilities for the calculation of KL include: (1) Using studies with concurrent exposure data only (Henderson and Enterline, McDonald et al., Peto, and Dement et al.), which gives estimates of KL of 0.014 (arithmetic mean) or 0.006 (geometric mean); (2) using only the upper limits of the uncertainlty ranges, which gives a KL of 0.059 (arithmetic mean) or 0.02 (geometric mean).

The value of 0.01 falls well within the range of KL's suggested by participants in the rulemaking. It is less than two times larger than the lowest value suggested for KL (by Crump). In addition, as OSHA discussed in the proposal, there is a range of uncertainty associated with this value that more than covers all suggested values of KL. Thus, OSHA believes the value of 0.01 to be a valid, reasonable estimate of KL and has employed it in developing its estimates of risk to support these revised rules.

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II. Estimates of Risk for Mesothelioma

A. The Model. For the November proposal, OSHA chose an absolute risk model to predict the risk for mesothelioma from exposure to asbestos. Absolute risk is calculated as observed deaths divided by the number of person-years at risk. It is believed that use of SMR's or relative risk is not appropriate for mesothelioma because the expected number of deaths in a cohort would be close to zero due to the rarity of the disease. The use of absolute risk to predict risk of mesothelioma was not questioned by any participant in the hearing.

In addition to using absolute risk rather that relative risk, this model is different from that used for lung cancer because both duration of time since initial exposure and duration of exposure are determinative or risk. The magnitude of the risk increases linearly with intensity of exposure, whereas the risk increases exponentially with duration of exposure and time from onset of exposure. The rationale for such a model describing mesothelioma risk has been discussed by several authors [Armitage and Doll, 1969, Ex. 84-252; Pike, 1966, Ex. 84-385]. Such a model was utilized by Newhouse and Berry [1976, Ex. 84-342] in predicting mesothelioma mortality among a cohort of factory workers in England. Limited data from three studies are also available on the dose-response relationship for mesothelioma [Seidman et al., 1979, Ex. 84-87; Hobbs et al., 1980, Ex. 132, and Jones et al., 1980, Ex. 84-138].

The model used by OSHA to assess the risk and derive the potency factor for mesothelioma, KM, is given by the following equations:

ARM=fxKM[(t-10) 3 -(t-10-d) 3]

for t+-10+d

ARM=fxKM(t-10) 3

for 10+d>t+-10

ARM=0

for 10>t

where ARM is the excess mortality from mesothelioma, f is the intensity of exposure in fibers/cc, d is the duration of exposure in years, t is time after first exposure in years, and KM is the proportionality constant that is a measure of the mesothelioma carcinogenic potency (slope of the dose-response curve) [Ex. 84-392].

Dr. Marvin Schneiderman discussed several aspects of the choice of this model for assessing mesothelioma risks. In his written testimony he stated:

The formula for estimating mesothelioma risk has a somewhat different form [from that of lung cancer]--in keeping with the fact that the excess risk from mesothelioma is measured as an "absolute" rather than a "proportional" risk. . . .

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What these formulas say is, first, no disease will be seen sooner that 10 years after first exposure (induction period effect). Second, if d is relatively short (compared to t) then there will be less disease than if the duration of exposure is long. Finally, the age-at-first exposure effect is subsumed in the exponent 3.

The Consumer Product Safety Commission, in the report mentioned above [Ex. 84-256], also gives this formula. The NRC/NAS report on asbestiform fibers [Ex. 321] notes the great sensitivity of the estimate to the exponent of the (t-10) [and the (t-10-d)] term. Taking the term (t-10) 3 as a base, if t=40, the relative values of the term raised to different exponents are:

NRC/NAS 'middle'	:(t-10)	[FN3.2]	1.97x(t-10) [FN3]
Peto, et al.....	:(t-10)	[FN3.5]	5.48x(t-10) [FN3]
Nicholson	:(t-10)	[FN4]	30.0x(t-10) [FN3]

These values are somewhat different if the "delay" term is neglected [Ex. 116, p. 6-7].

In his written testimony, Dr. Crump raised several issues concerning the choice of this expression for the time factor. He stated:

Most studies of mesothelioma predict that the mortality risks are a power of elapsed time since first exposure, as assumed by the OSHA model. However, we cannot be sure that this steep rate of increase extends indefinitely into old age as assumed by OSHA. In the Selikoff cohort, which contains the best information on mesothelioma mortality in old age, the number of mesotheliomas in the oldest group (55+ years since first exposure) is only about 1/2 the number predicted from the OSHA model. Although some of this shortfall may be due to underreporting in old age, it is also possible that the deficit is real. If so, the OSHA model will overestimate risk at oldest ages. None of the cohorts contain information on mesothelioma risk after 30 years past termination of exposure. OSHA's assumption that the risk will continue to increase represents an assumption which is not presently verifiable [Ex. 237A, p. 34].

In a post-hearing comment, Dr. Crump extended his argument. In addition to the data from the Selikoff cohort discussed above, Dr. Crump also discussed the mesothelioma data from the recently completed follow-up of the Seidman et al. study of amosite workers. He pointed out that for these data, ". . . the mesothelioma rate did not continue to raise with increasing age from first exposure, but dropped off 35-40 years from first exposure to 1.8/1000 person-years, which is about 1/3 of the rate observed for 30-35 years from first exposure" [Ex. 312a, Vol. I, Tab A, p. 7]. Dr. Crump noted that, although the OSHA model assumes "that the mesothelioma mortality rate increases indefinitely as a power of time from first exposure . . . the multistage model does predict an eventual reduction, the timing of which is determined by the number of stages affected and the rate of

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elimination of fibers from the body" [Ex. 312a, p. 8]. Dr. Crump went on to conclude that "if the reduction is real, then the OSHA model will provide a considerable overestimate of ***22639** mesothelioma risk from exposures in early life" [Ex. 312a, p. 8].

In addition, Crump performed a statistical analysis which demonstrated that the use of a delay model (such as the one proposed by OSHA) will always result in higher estimates of mortality rates at older ages than use of a model which does not incorporate a delay. He concluded that "Thus, rather than compensating for the reduction in risk, OSHA's use of a model with a delay exacerbates the tendency to overestimate risk at older ages" [Ex. 312a, p. 9].

As pointed out by Drs. Crump and Schneiderman, most studies of mesothelioma risk demonstrate that mortality risks are a power of elapsed time since first exposure, and this formulation has received widespread support. In general, the selection of a power of 3 is a reasonable choice and has been used by other reputable bodies (e.g. CHAP, Ex. 84-256). As noted by Dr. Schneiderman, the choice of a power of 3 will tend to give lower estimates of risk other choices of exponents which are also consistent with the available data. In addition, while Crump raised some doubts about the use of a "delay" model, the model also has widespread support in the scientific community (e.g. NAS/NRC, Ex. 321, CHAP. Ex. 84-256). Moreover, Dr. Crump's multistage model also contains a form of delay.

While there is some indication that these risks are, by no means overestimates, the benzene decision gave OSHA leeway to make assumptions which err on the side of overprotection of workers. Thus, OSHA believes the model it has used in the proposal to predict mesothelioma to be a reasonable consideration of the available data and has not changed it for the final rule.

In addition to the selection of the time factor, Dr. Crump also expressed concern over OSHA's assumption that the dose-response relationship was linear. He noted that:

The second assumption, namely a linear dose response, is particularly subject to doubt for mesothelioma because there is virtually no dose response data for this cancer. Finkelstein (1983) [Ex. 84-240] contains a table showing dose-response data for mesothelioma derived from a total of only nine mesotheliomas. The Simpson Report (Health and Safety Executive, 1979 [Ex. 84- 216]) contained a table (Table 31X) showing a dose response for mesothelioma derived from a case control analysis of data of McDonald et al.; however, the table did not appear in the published paper (McDonald et al., 1980) [Ex. 237A, p. 35].

Crump plotted the Finkelstein mesothelioma data with linear, quadratic and cubic dose-response curves and observed that "The linear model appears to fit only slightly better than the quadratic, and even the cubic model falls well within the crude 90% confidence bounds" [Ex. 237A, p. 36]. Crump concluded that:

Consequently, a linear dose response for mesothelioma is an assumption which has

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not been verified observationally. Since it seems biologically implausible that a dose response for cancer would ever be supralinear (Crump 1984) the linear assumption appears very unlikely to lead to an underestimate of risk from exposure to low concentrations. However, it could possibly provide an overestimate. There have been two general arguments which suggest that a linear dose response is plausible for many carcinogens. One such argument applies for carcinogens that "act by directly causing a mutation in DNA" (NRC, 1977). However, this argument may not be applicable to the carcinogenic mechanism of asbestos in producing mesotheliomas because asbestos has not been shown to be particularly mutagenic. The other general argument holds for carcinogens that produce cancers by the same mechanism by which background tumors are produced (Peto, 1978). However, since the background rate of mesotheliomas is either zero or--at most--very small, this argument is not applicable either [Ex. 237A, p. 36].

In an effort to investigate the effects of the choice of the model for mesothelioma, Crump fit a multistage model to the mesothelioma data used by OSHA. He described the model thus:

The multistage model, in its most detailed and complete form (Day and Brown, 1980 and Crump and Howe, 1984), is derived from the assumptions that cancer is initiated in a single cell only after the cell passes through several stages. Cells compete independently to be the first to produce a tumor. The rate at which a cell passes through a dose-related stage is assumed to be proportional to the instantaneous dose.

The model predicts a linear response at low dose whenever either 1) cancers occur "spontaneously" without a carcinogenic insult, or 2) there is only one dose-related stage; otherwise the model predicts a nonlinear response (Crump et al., 1976). The evidence for spontaneous occurrence of mesotheliomas is lacking; consequently, the only way the multistage model can predict a linear response at low dose is for there to be only one dose-related stage. Since there is essentially no dose-response data for mesothelioma, the number of dose-related stages for mesothelioma is open to question [Ex. 237A, p. 44].

At the hearing, Dr. Nicholson defended the use of the linear dose-response assumption to predict mortality from mesothelioma, stating that:

There's no indication that mesothelioma develops as a result of asbestos fibers acting separately at different stages in the cancer process, which would be required in the multi-stage model to elicit a nonlinear response.

I know of no mechanistic basis that . . . or no experimental data that indicate that that is the case at all.

The limited data what we have, and it is less than that for lung cancer, suggests that linearity is compatible with the data that exists. The data are sufficiently uncertain that one can't say that absolutely linearity is the case. The fact that it's applicable in the case of lung cancer, [a]nd has plausibility of an

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asbestos fiber doing something, [a]nd the probability of that something being done would be proportional to the number of fibers available to do it exists, and, thus linearity is a most reasonable choice. . . .

One could envision, for example, that mesothelioma comes from those fibers that manage to penetrate the lung wall and get to the pleura. And that in heavy exposure circumstances, the fibrosis that would be present would limit the number that would cross the wall. Thus, you would have in the heavy exposed circumstances fewer mesotheliomas because fewer fibers can penetrate to the pleura than in lower exposure circumstances, giving you a concave downward dose response relationship.

That's just a speculation, as is the speculation of a multi-fiber action at one site. And I don't think either have sufficiently substantive backing to deviate from the use of the linear dose response relationship, which has stood us in good stead in most other circumstances [Tr. 6/19, p. I-140-142]

[Note: The following TABLE/FORM is too wide to be displayed on one screen. You must print it for a meaningful review of its contents. The table has been divided into multiple pieces with each piece containing information to help you assemble a printout of the table. The information for each piece includes: (1) a three line message preceding the tabular data showing by line # and character # the position of the upper left-hand corner of the piece and the position of the piece within the entire table; and (2) a numeric scale following the tabular data displaying the character positions.]

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Table 3.-- Estimates of KM and Goodness of Fit From Six Studies of

		Selikoff (180)b	Seidman (14)	Finkelstein (11)
OSHAc	KMd	1.0	5.7	12
	Pe	0.07	0.74	0.39
MS1f	KM	110	300	7,800
	P	0.76	0.12	0.97
MS2g	KM	12	100	270
	P	0.62	0.39	0.99
MS3h	KM	0.59	2.4	15
	P	0.62	0.73	0.83

a Crump (Ex. 237A).
b Number of Mesothelioma Deaths.
1...+...10....+...20....+...30....+...40....+...50....+...60....+..

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******* This is piece 2. -- It begins at character 68 of table line 1. ********
****

Occupational Exposure to Asbestosa

Peto (7)	Dement (1)	Weill (2)
0.7	0.22	0.07
.99	0.67	0.001
40	12	3.6
0.99	0.32	0.037
1.9	4.4	0.76
0.99	0.39	0.39
0.061	3.1	0.016
0.99	0.39	0.90

68.....+...80....+...90....+....0...

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**********************************************************************************
******* This is piece 3. -- It begins at character 1 of table line 17. ********
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c Estimates derived from OSHA model (Ex. 84-392). P values and KM for Dement et
  al. and Weill et al. from Crump (Ex. 237A).
d KM x10.8
e P Value associated with Chi-squared goodness-of-fit test.
f Estimates derived from multistage model with one dose-related stage.
g Estimates derived from Multistage model with two dose-related stages.
h Estimates derived from multistage model with three dose-related stages.
1...+...10....+...20....+...30....+...40....+...50....+...60....+...70....+....
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